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TESTING SHIP FITTINGS

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5. Materials for Ship Fittings

The operational reliability of ship fittings, their efficiency, and service life depend to a considerable degree on the material used in individual structural units. The importance of the material used is especially great in high parameter fittings.

At high temperatures, material strength decreases, while plasticity increases. A pressure increase of the medium causes complex stresses in the fittings. Moreover, alternate stresses have harmful effects on materials and can enable even small loads to cause failure.

It is necessary to know the properties of materials used in ship fittings in order to select the correct operating conditions and testing parameters as well as to correct defects.

Depending on the intended use of the individual units, materials for ship fittings can be classified in the following manner:

1) materials for control elements;
2) materials for drives;
3) materials for bodies and covers;
4) materials for gaskets and packings;
5) materials for fastenings;
6) plastics.

Materials for Control Elements. As has been noted, the following pertain to control elements: spindles, rods, axles, and locking couples (plate or disc and sealing socket in the body). In the technical literature, sealing rings sometimes refer to body elements.

The materials used in spindles, rods, and axles have to be corrosion-resistant and have a relatively high surface layer hardness, resistance against seizing, and high strength at given temperatures.

Particularly high requirements are put on materials used in locking couples. They must be corrosion-resistant, have constant mechanical properties, high hardness, and be especially erosion-resistant. Moreover, these materials must be seizure-resistant and have good lapping properties. The efficiency and reliability of fittings depend essentially on the operation of this couple.

The requirements enumerated above are put on the materials used in the parts of control elements, depending on how the fitting is used, its type, and parameters. An incomplete list of materials used is given below:

Steels

St. 5	0Kh18N9	12KhMF
25	Kh25N13	4Kh14N14V2M
35	Kh25N20	15Kh1M1F
40Kh	Kh17N10T	25Kh2MFA
20KhM	Kh18N12M2T	35KhM10A
1Kh13	Kh18N12M3T	38KhMYuA [35
2Kh13	1Kh17N2	38KhVFYu
3Kh13	1Kh18N9T	

Brasses

LS 59-1	LK 80-3	LMtsS 58-2-2
LS 59-1L	LK 80-3L	LZhMts 59-1-1

Bronzes

Br. AZhMts 10-3-1.5	Br.AZhN 10-4-4	Br. OTs 10-2

Special Alloys

Stellite VK3	Sormite No. 2	Alloy TsT-2
Sormite No. 1	Alloy TsT-1	Alloy TsT-2

Materials for Drives. Fitting drives, regardless of design, are usually not subjected to the action of the medium passing through the fitting. Therefore, in the case of drive details, selection is limited by the materials that usually go into the manufacture of reduction gears and similar mechanisms.

Materials for Bodies and Covers. Depending on the intended use, body and cover materials in a fitting can be divided into several groups: materials for fitting bodies operating at normal (moderate) parameters, those of a special fitting operating under unusual conditions (seawater, carbon dioxide, etc.), and those of a fitting operating at high temperatures and pressures.

Fitting bodies have complex configurations and are therefore usually made by casting. Small-section bodies are usually forged or stamped, while larger ones are welded or cast welded.

The manufacture of high parameter fitting bodies is particularly difficult. Experience has shown that the main difficulty in manufacturing such equipment has been that of ensuring air-tightness over long periods of use. High pressure, the high flow velocities of the medium, sharp temperature changes, and the heat expansion of component details increase leakage, and cause erosion and seizing. All of these factors require therefore the use of special high-alloy steels and a special manufacturing technology.

Depending on the composition of the conducting medium, its temperature and pressure, carbon and alloy steel, grey and malleable cast iron, bronze, brass, and their alloys are used to manufacture bodies and covers of fittings.

Tables 2-4 give the basic materials and conditions of use in depending on temperature.

Table 2. Irons Used to Cast Bodies, Covers and Other Shaped Parts of Fittings [36

Material	Limiting parameters: Pressure to $P_{cond.}$ kG/cm² (n/m²)	Limiting parameters: Temperature °C	Type
Grey iron	16 $(15.7 \cdot 10^5)$	−15 +300	SCh15-32 SCh18-36 SCh21-40 SCh24-44 SCh28-48
High-strength iron	25 $(24.5\ 10^5)$	−15 +300	VCh45-5 VCh40-10
Malleable iron	$D_{cond.} \leq 80$ $P_{cond.} \leq 40$ $(39\ 10^5)$	400	KCh30-6
	$D_{cond.} = 100 \div 150$ $P_{cond.} = 25$ $(24.5 \cdot 10^5)$	300	KCh33-8

Table 3. Steels Used in Body Details of Fittings [36

Type	Limiting temperature, °C	Type	Limiting temperature, °C
St. 3	-39; +300	16M	450
St. 4	-30; +300	Kh17	450
St. 5	-30; +300	Kh18	450
M21	-30; +300	2Kh13	425
25	-40; +450	15KhM	540
40	-40; +450	35KhM	500
40Kh	450	12KhMF	575
20L111	-40; +425	1Kh17N2	450
25L111	-40; +425	25Kh2MFA	530
20KhML	-40; +540	EI578	550
20KhMFL	575	EI612	650
Kh5TL	425	0Kh23N28M3D3T	-196; +400
Kh5ML	550	0Kh18N10T	-196; +600
Kh5VL	550	Kh18N10T	-196; +700
Kh8VL	575	Kh18N12M2T	-196; +600
0Kh18ML	-196; +700	Kh18N12M3T	-196; +600
Kh18N9TL	-196; +700	1Kh13N16B	600
Kh18N4G4L	450	1Kh13N18V2B	650
Kh18N12M2TL	-196; +650	1Kh18N12T	700
Kh18N12M3TL	-196; +650	1Kh14N14V2M	700
20KhMFL	585	1Kh14N14V2MT	700
20Kh1M1FL	565		

Materials for Gaskets and Packings. Materials for stuffing-box packings have to have high elastic properties, physical stability at operating temperatures, chemical stability against the working medium, the lowest possible coefficient of friction.

Cotton materials, hemp, asbestos cord, graphite, fluoroplastics, etc. are chiefly used as packing materials. Packings are manufactured in the form of plaited cord (rectangular or circular section), but plain rolled cord, without plaited or combed fibers, can be used. In some cases, packings are made from previously prepared and shaped rings. [37

Materials for stuffing-box packings and conditions for their use are listed in table 5 in relation to the medium parameters.

Gaskets have to retain their physical properties at the working temperature of the medium and not be subjected to corrosive action. The material of metal gaskets, to avoid deformation of the sealing surfaces, must have hardness and a yield point lower than that of the sealing surfaces of the flanges or pipes. Moreover, the materials used in gaskets and fitting cannot form an electrolytic couple in a given medium.

The coefficient of linear expansion of the gasket material ought, as far as possible, be close to that of the material used in the fitting.

Table 4. Nonferrous Alloys Used for Body Parts of Fitting [37

Material	Brand	Limiting temperature, °C
Brasses	LMts58-2 LK80-3L LO62-1	250
Bronzes	BrOTs8-4 BrOTsSN3-7-5-1 BrAZhMts-55-3-1 BrAZhMts10-3-1.5	130
Light alloys	AL2 AL6 AL8	75

Table 5. Materials for Stuffing-Box Packings 138

Material	Form used	Working medium	Limiting parameters °C	$P_{working}$ kG/cm² (N/m²)
Cotton	Fiber	Cold & hot water	100	200 ($196 \cdot 10^5$)
Hemp	Combed fiber, greased	Cold & hot water	100	160 ($157 \cdot 10^5$)
Dry asbestos	Fiber or cord	Hot dry gases, corrosion media	550	—
Impregnated asbestos	Plaited cord, impregnated with various compositions	Water, steam, other	300	—
Rubberized vulcanized asbestos	Rubberized vulcanized cord (NVDT-1)	Water, steam petroleum products, etc.	200	325 ($318.7 \cdot 10^5$)
	Rubberized vulcanized cord with brass wire (NVDT-2)	Water, steam petroleum products, etc.	200	700 ($686 \cdot 10^5$)
	Rubberized vulcanized cord with brass wire (NVDT-2s)	Water, steam petroleum products, etc.	450	700 ($686 \cdot 10^5$)
Asbestos with graphite	Graphite-impregnated asbestos ring with graphite layering	Water, steam	400	—
	"Pushonka"-flaked asbestos mixed with flake graphite	Water, steam	510	—

Flake graphite	Flake graphite; top and bottom along asbestos ring Graphite paste Pressed graphite rings and half rings	Water, steam, etc.	550 & above	--
Fluoroplastic-4 (Teflon)	Shaving, rings or cup leathers	Corrosion media	From -195 to +250	100 $(98 \cdot 10^5)$
Fluorolon	Packing	Mineral acids	100	--
Fiberglass	Fibrous material	Corrosion media	100	--
Fluoroplastic packing material FUM-V	Rectangular or circular section cord	Corrosion media	-60 +150	64 $(62.7 \cdot 10^5)$

Gasket materials and their applications are given in tables 6 and 7.

Combined asbestos-metal and spirally plaited gaskets fall in a special group [24]. The former are made of sheet metal (aluminum, lead, copper, steel, etc.) with an asbestos filler. When the materials are properly selected, these gaskets can be used in a wide working medium temperature range.

Spirally plaited gaskets are made from profiled rust-resistant narrow strips (brand 0Kh18N10) and of paronite strips. They are used in the fittings of main steam pipes and pressure-feed pipes. Owing to their design, both kinds of gaskets have elasticity and strength, and do not require great specific pressures in compression. In addition, they permit a rougher finishing of joined flange surfaces.

Materials for Fastenings. The main kinds of fastenings are bolts, studs, and nuts. Carbon and in some cases alloy steels are used in their manufacture,

Table 8 lists the brands of steel used in fastenings of ship [40
fittings and the conditions under which they are used in relation to medium temperature.

Plastics Used in Ship Fittings. Of late, increasing attention [41
is being given to the use of various plastics in manufacturing fittings. Their production continues to increase, the list of products is expanding, and quality is improving.

Compared with metals, plastic structures are considerably lighter, have a longer service life, and are less laborious to manufacture.

However, plastics also possess several properties that prevent their finding broader application in manufacturing ship fittings As is known, the limiting temperature of most plastics is 100-120° C; only fluoroplastic 4 [Teflon] has a heat resistance of about 250° C.

Moreover, special equipment (molds, casting machines, etc.) is [42
required to produce plastic fittings. This could be unprofitable when small-lot production is involved. For these reasons, only certain of the plastics known to technology are used to manufacture ship fittings and individual details of fittings.

It must be noted that details made from plastics, like those from metals, can be cast, molded, cut, welded, and can also be joined by baking and spraying. Spraying is a process of applying thin plastic layers to metal surfaces in order to protect the basic metal from corrosion or the erosive action of aggressive media, or to provide a

Table 6. Nonmetallic Gasket Materials

Material	Medium	Limiting temperature, °C
Rubber	Water, oil, petroleum products	150–200
Packing board	Water, steam	120
	Oil	80
	Petroleum products	85
Asbestos	Hot gases and air	600
Paronite	Water, steam, and petroleum products	450
Polyvinyl chloride plasticized substance	Corrosion media	-15; +40
Polyethylene	Corrosion media	-60; +50
Vinyl plastic	Corrosion media	65
Fluoroplastic 3 (Kel-F)	Corrosion and aggressive media	-60; +70
Fluoroplastic 4 (Teflon)		-195; +200

decorative surface finish. Powdered thermoplasts like polyamides P-67, PS-7, propylene, and others, are used for spraying. Fittings are also lined with fluoroplastics, polyethylene, and other plastics for protection.

The use of plastics in the manufacture of welded articles of fittings depends on their technical characteristics.

Plastics are welded at different temperatures and in different ways. The most widespread plastics welding methods are: heat-carrier welding, contact welding, high-frequency current welding, ultrasonic welding, and friction welding.

In addition, various combinations of these methods are used.

The kinds of plastics used in ship fittings and their properties are given in table 9.

Table 7. Metals Used to Manufacture Gaskets [39

Metal	Brand	Medium and using conditions	Limiting temperature, °C
		Water vapor	475
Armco iron	05KP (special)	Sulfur-containing alkalis, acids, gases. Unsuitable for water solutions of acids and alkalis.	320
Steel	15-30	Water vapor and petroleum products	550
Corrosion-resistant	0Kh18N9, Kh18N10T	Water vapor, petroleum products, corrosion media, except sulfuric acid	(-196); (+600)
Aluminum	A2	Air, water	430
		Petroleum products and acids	(-198); (+300)
		Water vapor	430 [40
Nickel	NT	Chlorine and others	(-180); (+450)
		Oxidizing media	750
Monel metal	NMZhMts 28-2, 5-1.5	Water vapor	430
		Corrosion media	800
Copper	M1, M2	Alkaline solutions. Unsuitable for steel flanges in the presence of water; salt, acid, and alkaline solutions	(-180); (+300)
Lead	S2	Corrosion media, acids	(-180); (+100)

Table 8. Metals Used to Manufacture Bolts, Studs, Nuts, and Flange Joints [40

Brand of Metal		Limiting temperature, °C
Bolt or stud	Nuts	
St. 5	St. 3	350
40	30	425
35Kh	30	425
30KhM	30, 35Kh	450
35KhG2	30Kh	[illegible] 00
40KhFA	30Kh	[illegible]
25Kh2MFA	30KhM	510
2Kh13	2Kh13	425
15Kh11MF	15Kh11MF	500
1Kh17N2	1Kh17N2	450
Kh18N10T	Kh18N10T	(-196); (+600)
EI572	1Kh14N14V2M(EI257)	600
4Kh14N14V2M(EI69)	4Kh14N14V2M(EI69)	6[illegible]0
EI612	EI572	650
Br. AZhMts10-3-1.5	Br. AZhMts10-3-1.5	(-1[illegible]0); (+250)

6. Production Defects of Fittings

As a rule, such fittings production defects as the lack of hermetic sealing, unsatisfactory efficiency, inadequate reliability, etc. are detected when the fitting is tested. Some defects can be detected before testing by external examination, by measurement, or by comparison with a reference specimen. Primarily, this refers to the check of individual details and units before assembly.

Let us examine the possible defects of each of the component parts of a fitting.

Control Element Defects. The basic requirement placed on control elements, especially locking elements, is that they ensure a leakproof seal. The presence of a leak when this unit is being tested indicates a defect in the locking couple.

In bodies made of copper alloys, the sealing surfaces are machine finished and the relevant elements are lapped in. Poor-quality lapping [43 could cause leakage in them.

In bodies made of carbon steel, the sealing surfaces are made by facing special alloys or by mechanically fastening insertion rings made of copper- or nickel-alloys as well as from stainless and nitrided steels.

Table 9. Plastics Used in Ship Fittings [41

Material	Limiting temperature, °C	Basic properties and ways of working
Ebonite	65	Cutting
Rigid PVC plastic	60	Hot-air welded at temperature of 110-120° C, profiled by heating.
Polychloride vinyl plasticized substance	40	Soft, easily bent, hot-air welded
Faolite	100	Casting
Fluoroplastic-4 (Teflon)	250	Cutting
Fluoroplastic-3 (Kel F)	70	
Textolite	100	Cutting
Getinax	150	Cutting
Polyethylene	50	Hot-air welding
Polyvinyl butyral	70	Spraying
Epoxy resins	100	Has good adhestive properties, easily formed
Capron	70	Casting, spraying, cutting, welding, glueing.
Laminated DSP-F plastics	100	Forming, cutting.

Electric-arc welded sealing surfaces are most widespread in ship fittings. Such surfacings are made on bodies, plates, and discs.

The major defects of surfacings are porosity, cracks, nonfusion, slag inclusions, and insufficient layer thickness.

Porosity occurs when gases absorbed from the atmosphere and gases formed as the result of chemical reaction do not have time to escape from the metal being surfaced because of rapid cooling and hardening. In addition, porosity may be caused by defective cleaning of the surface to remove oil, rust, and other contaminants. In the case where pores are detected in the surfacing of a well cleaned surface, the correctness of the electrode coating composition should be checked, its state, and surfacing conditions.

The formation, after surfacing, of thermal stresses and the appearance of cracks can result from nonuniform heating and cooling. To prevent this defect, it is necessary to work on the heating and thermal treatment conditions.

Nonfusion is the local absence of fusing between the basic and surface metals or between layers of the surfacing metal. Nonfusion may be caused by inadequate welding current power, excessively rapid electrode displacement, incorrect groove preparation, and unsatisfactory cleaning of its surface. Nonfusion also results when molten electrode metal hits an inadequately heated basic metal. Thus, to prevent this defect, technological requirements must be strictly satisfied.

Slag inclusions are observed in multilayered surfacing, as a rule, because of insufficiently careful cleaning of slag, oxides, and cinders from the surface as well as when the electrode coating composition is unsatisfactory.

When the above enumerated surfacing defects are detected, the defective parts must be carefully cleaned and again surfaced with the necessary alloys. Scratch marks, notches, and dents are removed from sealing surfaces by mechanical finishing.

In some ship fittings, sealing units are packed with soft packing pieces (leathers, rubbers, plastics). The cause of leakage in these is usually the low quality of the packing pieces, incorrect arrangement, breaks, etc. To eliminate leaks in such seals, it is necessary either to replace or correctly rearrange the soft packing pieces.

Drive Defects. Characteristic drive troubles are assembly defects. In mechanical and electromechanical drives, they are various misalignments, bad meshing of gears, seizing of spindle threads. In hydraulic and pneumatic drives, they are the lack of necessary tightness, pin misalignment, etc. /44

Electromechanical and electromagnetic drives may also have defects in the electrical circuit.

Body Defects. As has already been noted, bodies are classified according to the manner in which they were produced into cast, cast welded, and stamped. Most bodies of ship fittings are cast. Therefore we shall dwell on casting defects.

The main requirements for the geometry of castings are: coaxial alignment and flange perpendicularity to the axis of passage; flange parallelism; minimum warping and wall thickness variation; and minimum displacement of individual elements. All of these characteristics are regulated by technical conditions; they are checked visually and by special measurement gauges.

The main casting defects, from the point of view of quality, are: surface and through cracks; gas, earth, and slag cavities; contraction cavities and porosity; cold shuts; fins, tongues, and protrusions; mechanical damage; etc.

In order to select the proper method of correcting the defect, it is necessary to know where it is and how it developed.

Surface and through cracks are mainly in casting areas transitional to sections. Such cracks are identified only with great difficulty in castings that have not yet annealed; it is much easier to detect them after annealing.

Gas, earth, and slag cavities are usually to be found in casting surfaces. They differ in form and size. External cavities are determined visually, internal (concealed) cavities are detected during the casting finishing process and by special defectoscopic methods about which more will be said below.

Contraction cavities and porosity are usually found in casting transition zones and are usually hidden. These defects are detected during close external examination of the casting with probe detectors. During this process special attention must be directed to those areas of the casting where there are cracks and small depressions. In most cases, it is sufficient to hammer tap several times to detect cavities or porosity beneath depressions.

Cold shuts are defects that are easily detected during the external examination of the casting. They resemble slits with rounded edges and may be surface or through varieties. The nature of the defect is determined by examining the side opposite the one on which the cold shut is located. The presence of a slit on the opposite side indicates that the wall has a through defect.

Fins, tongues, and protrusions on the body of the casting are usually found near the casting box joint or where there are gaps between form parts. All of these defects are easily detected during external examination of the casting after it has been knocked out of the casting box. [45

Cracks, different kinds of cavities, porosity, cold shuts, and even mechanical damage can be corrected by repair welding. The small defects are meticulously cleaned, while the deep defects are dressed. This operation is accomplished with a mechanical chisel in special sound-proof cabins. The repair welding of the defects is performed according to existing GOST standards and plant instructions or production charts and with due account of the casting material. Slight porosity in castings made from nonferrous alloys, which operate in sea- or fresh water, or in petroleum, oil, and steam with temperatures not exceeding 130° C, is corrected by bakelite lacquer treatment.

Misalignments, wall thickness variation, and displacements of individual casting elements are eliminated by surfacing the metal with thin walls and by fusing the metal to thickened parts.

Fins, tongues, and protrusions on castings are cut down with pneumatic chisels or by gas or electric arc cutting.

Besides casting defects in cast-welded body structures, there can also be welding defects: porosity, cracks, nonfusion, and slag inclusions. Welding quality is checked by x-raying, ultrasonics, etc.

Packing Defects. Let us examine possible defects in spindle, axle, or rod outlet packing units; cover-body packings, etc. These defects are characterized by medium leakage during hydraulic testing. Medium leakage through stuffing box seals may be caused by poor-quality packing material or by nonconformity to the operating parameters of the fitting. Incorrect size of stuffing box chamber packing, incorrectly cut packing rings, and incorrectly established ring joints in the stuffing box chamber can be added.

Cases have been known where, because of extreme bolt tightening, the stuffing box cover sinks too deeply into the box chamber. In checking the outer size of the neck bushings and the inner size of the stuffing box chamber, it has been established that the fits were not in accordance with the design draft. As a result, the packing was squeezed into a gap and did not provide the requisite hermetic state.

The cleanliness of spindle, axle, or rod finish, and the absence of curvature, grooves, and other damage on them, also have a great effect on the packing quality.

Medium leakage through the packings of the first and second groups (plungers, plugs, and labyrinths) that exceed computed values indicate the presence of large gaps, i.e., that the required fits have not been observed. Leakage through bellows attests to the presence of a defect (cracks, breaks, etc.). This defect cannot be corrected and the bellows must be replaced.

Leakage where the terminal bushings of bellows have been welded [46
on to other details can be repair-welded.

Leakage in cover-body flange joints in most cases are caused by poor-quality gasket manufacture or by damaged flange sealing surfaces. Looseness could occur because of nonuniform and weak nut tightening on the flange joint and also because of flange deformation during sharp temperature changes of the working medium.

In a fitting with metal collar gaskets, the causes of leakage can be: roughness of teeth surfaces, lack of sealing zonules on gasket teeth, increased hardness of gasket material, irregular gasket thickness, or the presence of through slits.

Defects of Plastic Fittings. Experience in the use of plastics in ship fittings has been comparatively limited and consequently in manufacturing techniques have not been worked out with finality.

The technological processes that have gained acceptance in recent times, viz., centrifugal casting, spraying, molding, welding, etc., have their advantages and disadvantages. Thus, disruption of the technological casting process when using polyamides (capron, polycaprolactams, etc.) results in defective products. The following defects can occur.

Vesiculation and cavitation in the thickened product walls form as the result of slowness in charging the melt to the mold and insufficient rate of mold rotation.

Shrinkage depressions, holes, and porosity within thick-walled products occur because of overheating the melt and insufficient rate of mold rotation.

Cold joints and shuts on stock faces result from low melt or mold temperatures and insufficient rate of rotation.

Product brittleness can be caused by high monomer content (exceeding 2%) and high moisture content (exceeding 0.3%) in the raw material.

Product darkening results from oxygen penetrating the autoclave.

The following defects are noted when plastics are sprayed on the metal surface: cracks and dents in the applied layer, layer thickness does not conform to draft requirements, plastics hitting surfaces that are not supposed to be covered.

Moreover, owing to irregular pistol motion or nozzle shape irregularities, the layer can have a nonuniform thickness. This defect is easily corrected by additional spraying after the nozzle has been repaired.

Looseness in the adhesion of sprayed plastics to the metal surface could be caused by the following: inadequate heating of the mass or metal surface; air, mass, or metal surface contamination. When these defects are present and they cannot be corrected, the applied plastics layer must be removed. This is done in special annealing /47
ovens. Minor defects in covering are eliminated by sealing with a special electric solderer.

Characteristic defects in molded fitting details are: incomplete or porous product because the mold was not completely filled with mass; cracks and blisters in the product because of mold overheating; soft (unhardened) products because of the use of a green mass, inadequate curing time, or inadequate mold heating. In addition, if the mold has been poorly polished or has insufficient tapering, when the product is ejected it could be fractured; a green or poor-quality mass could stick to the mold.

Product quality, produced by molding, can be judged by their color. Thus, dull spots appear because the mold has not been heated adequately or because of too short mold curing time. Dark spots are caused by excessive lubrication of an unsuitable composition.

Welding defects in plastics can be divided into two groups: defects obtained when welding with a filler material and efects when welding without a filler material. Indications of the first case are given below.

Nonfusion and trimming occur through incorrect welding torch position or insufficiently high heat-carrier temperature.

Decomposition of the detail material and the weld seam is a consequence of excessively high heat-carrier temperature. Layering and bulging of the basic material in welding can be caused by multiple heatings.

Low mechanical strength of weld seams or seam surface color change result from contamination of the heat-carrier because of incorrect filtering.

When welding plastics without a filler material, the causes of defects are other factors. Nonfusion, for example, can occur because of a disruption of the technological process, i.e., increased welding speed, insufficient electric field voltage and welding instrument heating temperature.

Decomposition of weld seam material can be caused by high electric field voltage or overheated welding instruments. Color change in the weld seam material and the presence of side inclusions indicate that the surface of the welding instruments or electrodes are contaminated.

If the defective area cannot be corrected, it has to be cut out and welded again.

Besides these possible technological defects of plastic fittings, assembly defects must also be pointed out, viz., the lack of necessary seal tightness, misalignments, tight spindle movement, etc. Since the plastic fitting consists of the same details as the metal fitting, assembly defects are corrected in analogous ways.